Discom Production Test System

End-of-Line Quality Assurance

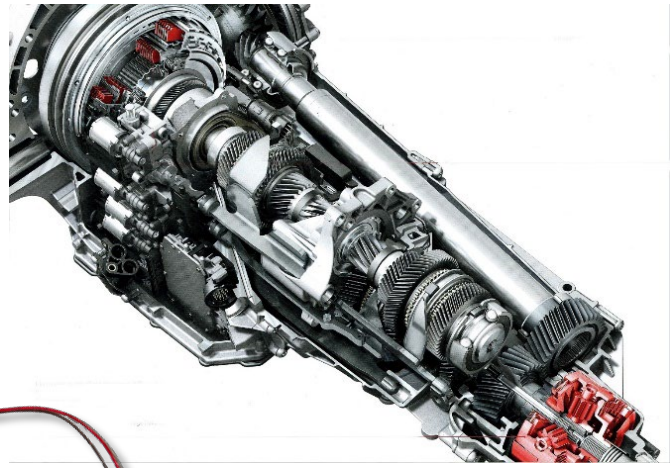
www.discom.de

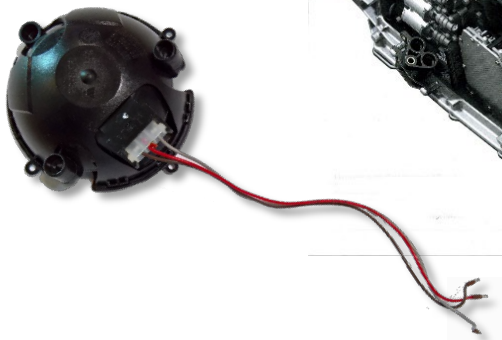
HBK
HOTTINGER BRÜEL & KJÆR

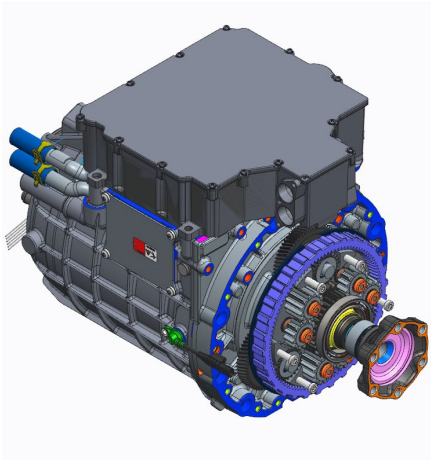
Discom Applications

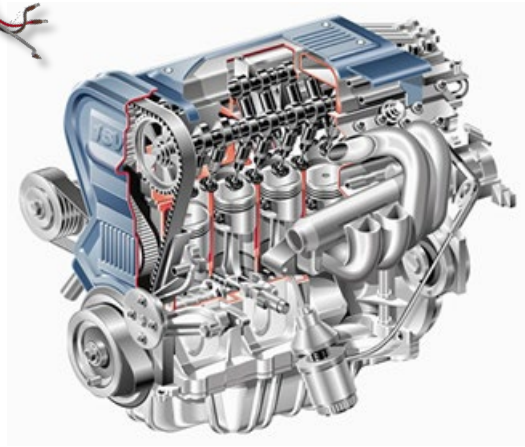
Discom End-of-Line test systems are used worldwide for

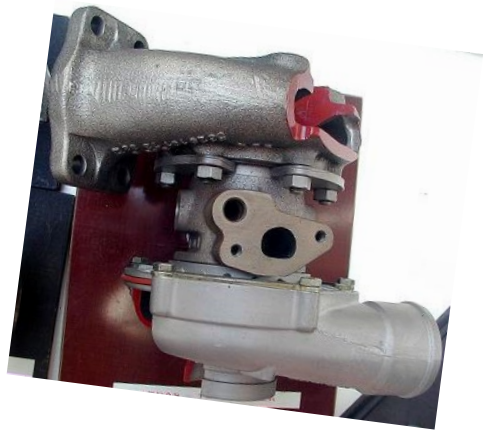
- Transmissions and gearboxes of all kind
- E-Drives and E-Motors
- Combustion Engines
- Actuators and small devices
- Turbochargers
- Gear testing
- Oil pumps and other pumps
- Durability of transmissions and E-Drives
- Mobile testing in cars

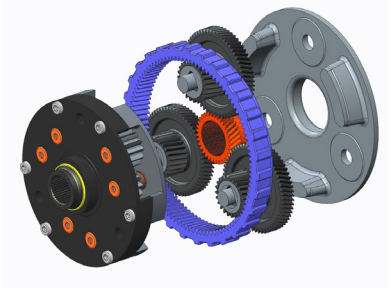






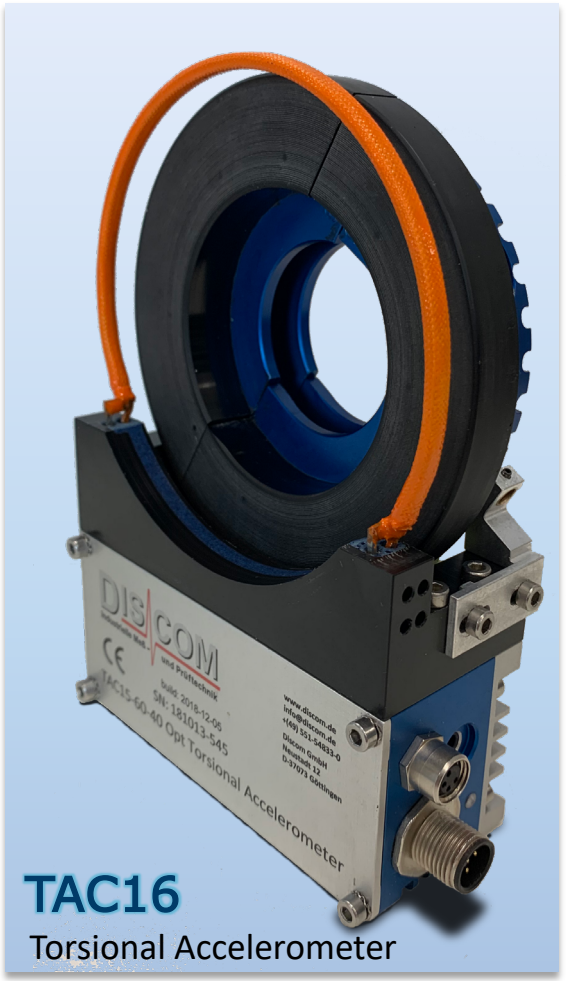






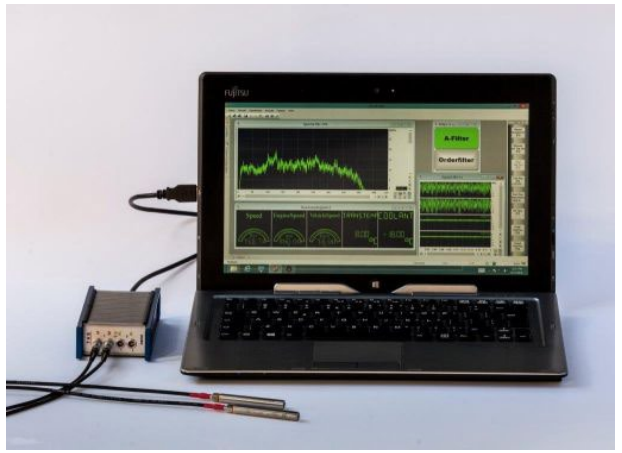
Discom Sensors for Production Environment

Discom has designed sensors and mountings specifically suited for production environment.



Tas Box Data Acquisition Front End

The *Tas Box* front end comes in different sizes, adapted for the use in a test stand environment.
Tas Boxes are USB devices which can be used with all kinds of Windows PCs, including tablets.

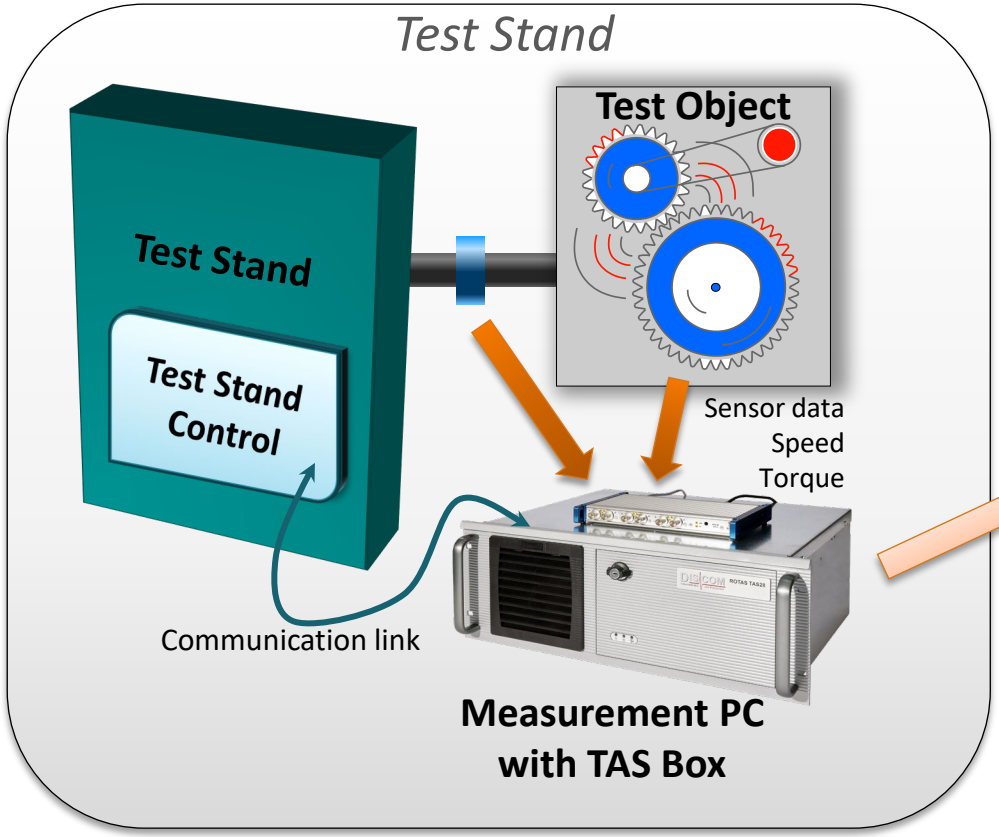


Technical data:

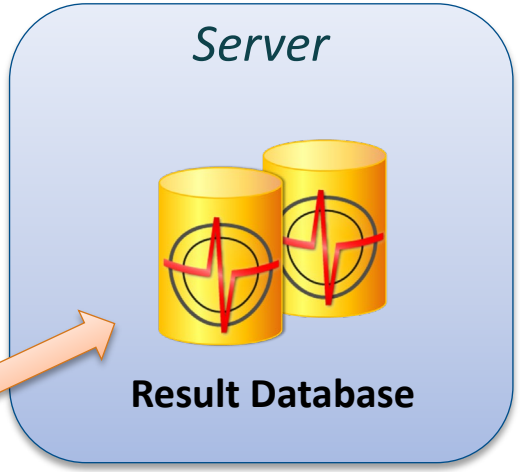
- Sampling rates up to 200 kHz, 24 Bit A/D converters
- A/D converter module: AC, DC or ICP coupling, input voltage up to 30V
- Modular system, can be extended for up to 16 A/D channels + 4 pulse channels for rpm speed
- Rpm speed module for pulsed speed signals with up to 10 MHz pulse rates
- Power supply for IEPE sensors; up to 5 only per USB power

Test Stand Environment

The measurement PC in the test stand processes the sensor data and communicates with test stand control.
All results are transferred into the central result database.
The Discom evaluation software tools can be used in any place.



Measurement application



For single test stand projects, the measurement PC can also take the role of the server.

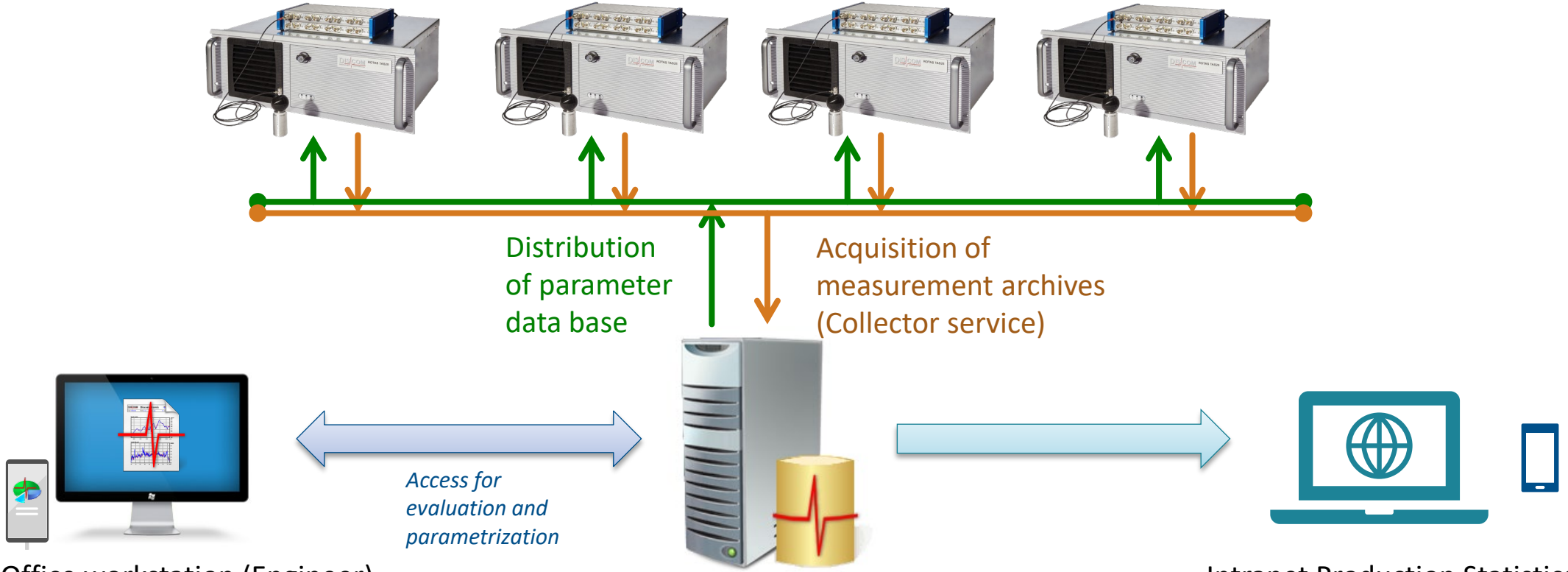
Evaluation software
Production statistics
Central parametrization

The Discom software suite consists not only of the measurement application, but also includes a suite of evaluation and administration tools.

Handling Multiple Test Stands

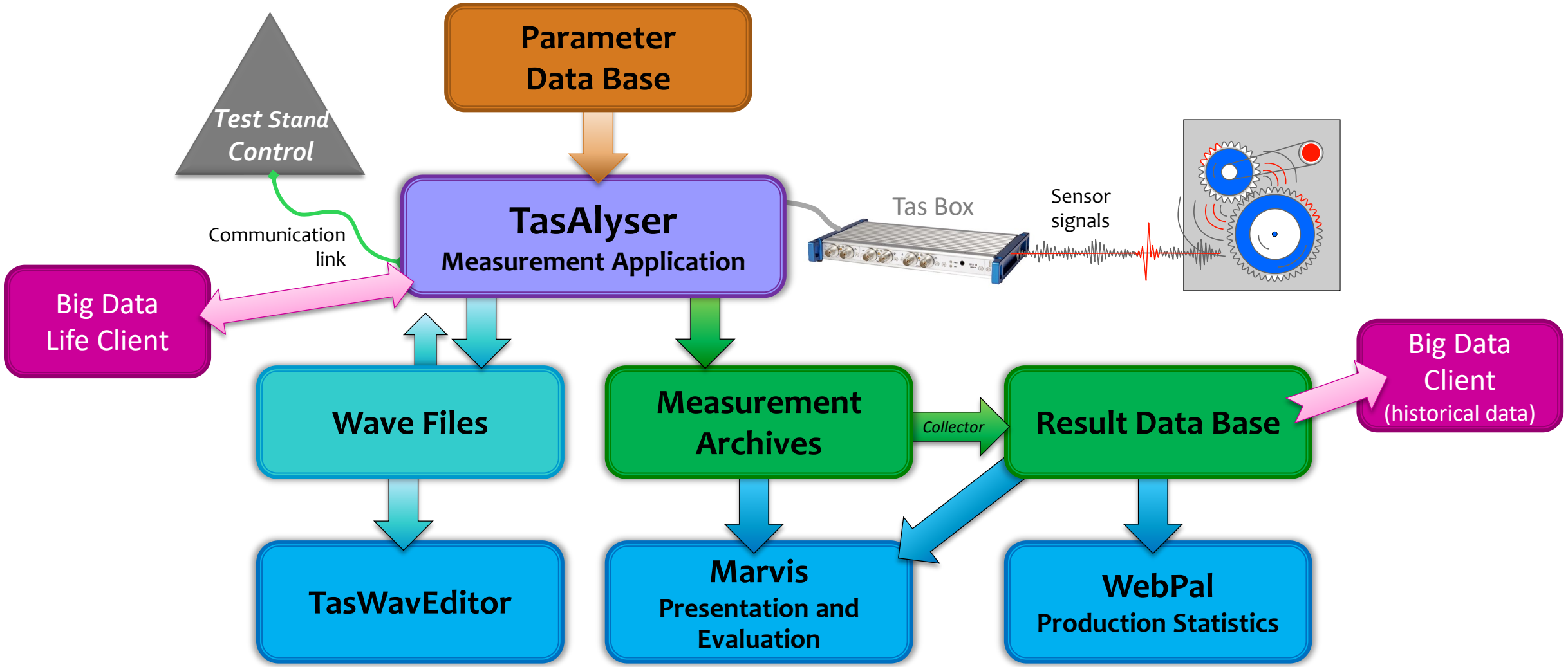
The Discom system is designed to be working on multiple test stands in parallel.

All test stands use the same parameter and result data base and are managed from the central server.
Parameter setting and result evaluation is done remotely from the user's desktop.



Discom Software Suite

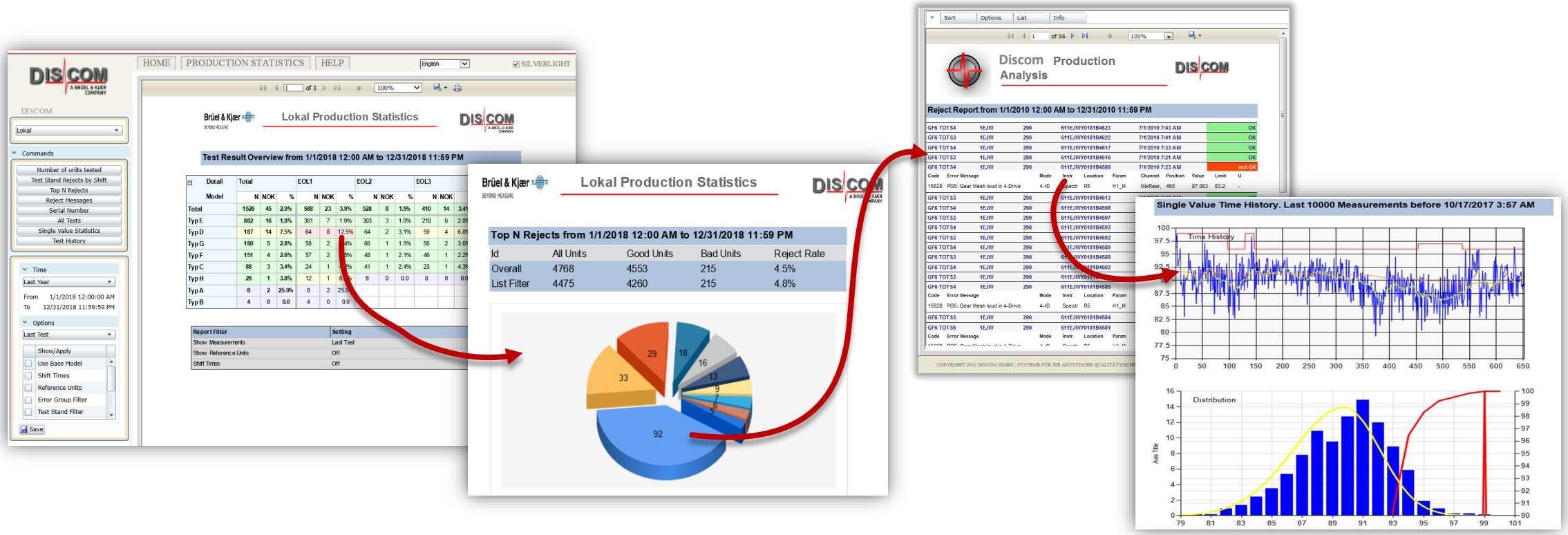
The *TasAlyser* measurement application is part of a software suite covering the whole production testing process, including interfaces to customer AI solutions.



Result Database and Production Monitoring

The result database holds measured values (including curves), limits, defect messages and evaluation results for every test run from every test stand in the line.

It can be accessed with the Marvis evaluation software or the WebPalViewer application. With VPN access to the result database server, statistical evaluations and production monitoring can be done from any PC in the company network worldwide, and also on mobile devices.



Analysis Methods

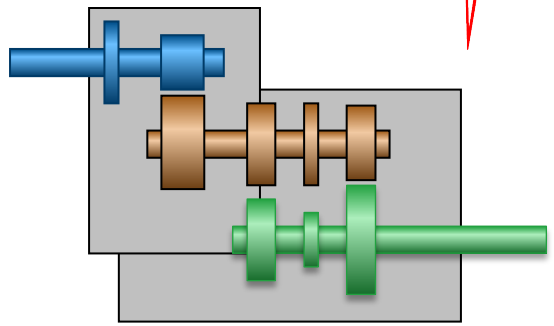
A core feature for root cause trackdown is rotationally synchronous analysis.

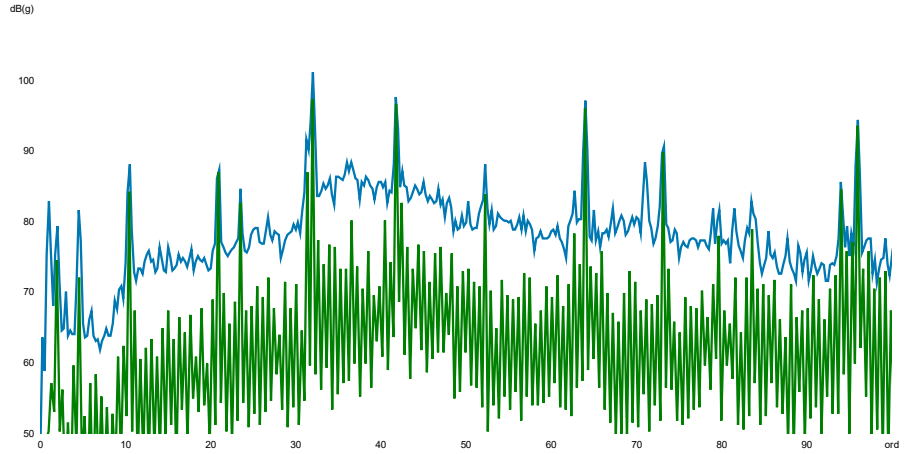
This enables the Discom system to separate noise sources in rotating systems like transmissions, E-Drives, Axles and Gearboxes.

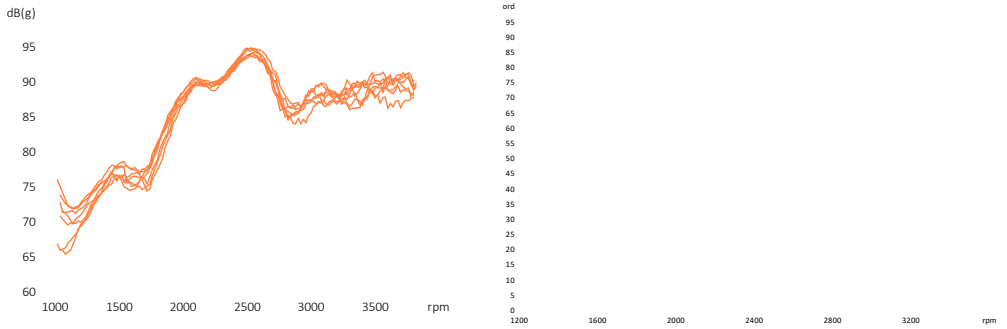
Rotationally synchronous analysis allows the calculation of exact order spectra (as opposed to scaled frequency spectra).

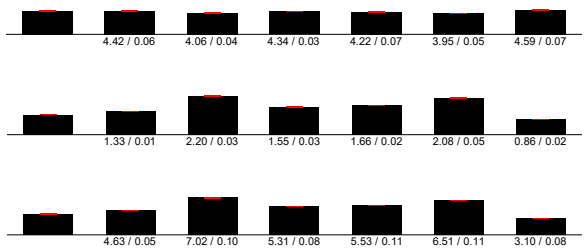
Starting from these, single orders or bands can be tracked over speed, torque or other control values. Spectra and tracks can be evaluated against limit curves; in addition, a vast collection of second-level analysis methods allows to evaluate specific features of the curves.

Spectrograms, Modulation analysis and operation cycle spectrogram add advanced analysis features.









Combining Automatic and Fixed Limits

In EOL testing, there are two major objectives:

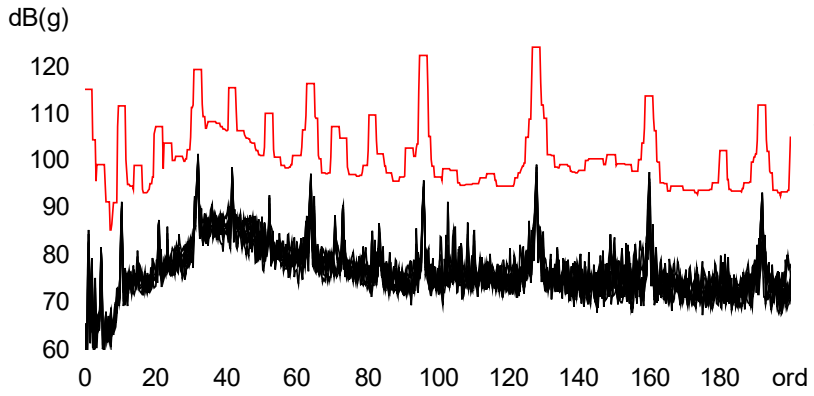
- Find pieces which will be audible in the car
- Find pieces with defects that limit the lifetime

This requires two limit strategies:

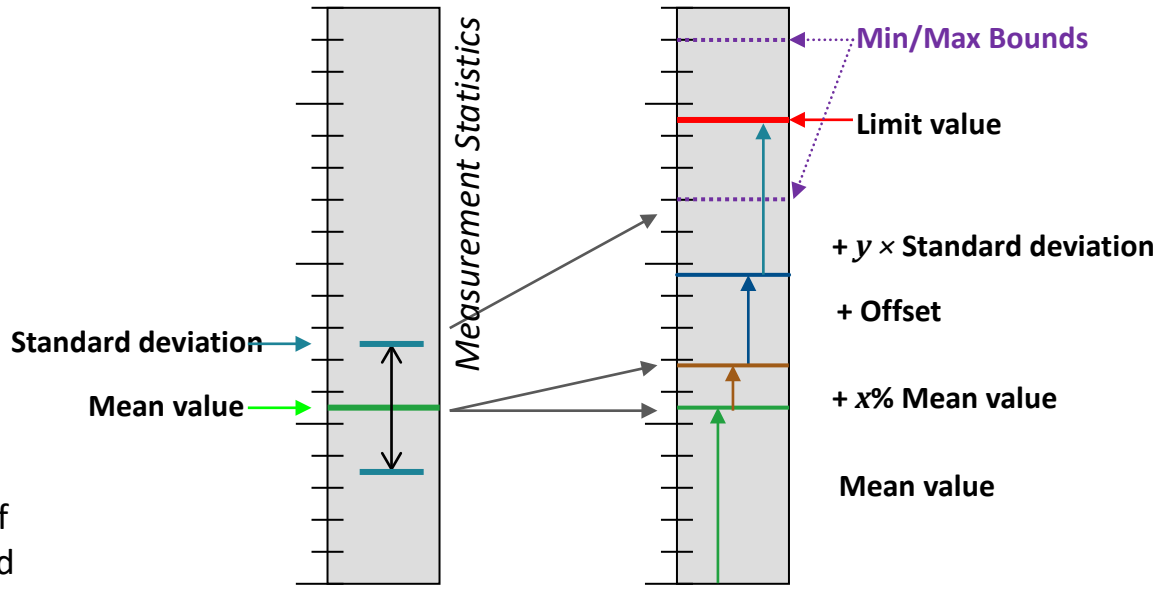
- Fixed limits confirmed by drive tests in car
- Automatically learned limits, based on statistics

The Discom system uses a combination of learned and fixed limits which give a high flexibility for all kind of situations.

The limit parameters are controlled in the parameter database, allowing for easy management even with many different types and test steps.



The combination of automatic and fixed limits also applies to limit curves



Calculation of the limit value:

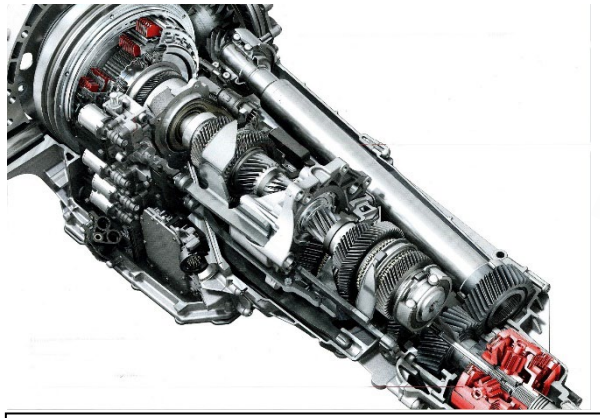
(1) Limit = Mean + x % Mean + Offset + y × Std.Dev.

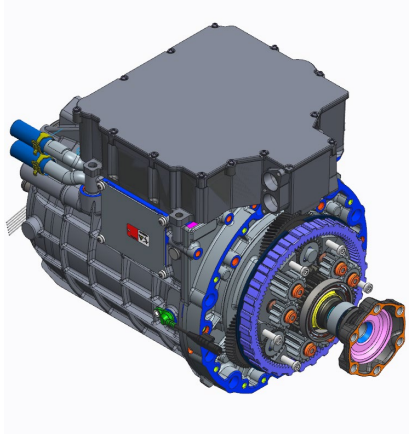
(2) apply bounds: *Min* ≤ Limit ≤ Max

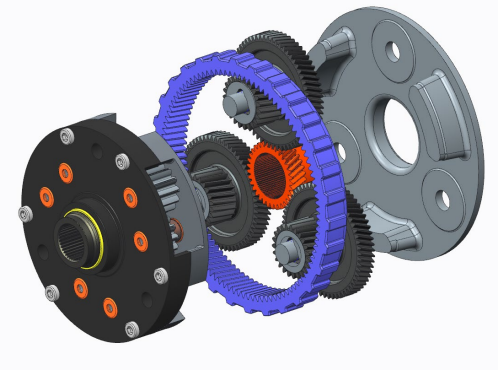
Transmissions: Rotationally Synchronous Analysis

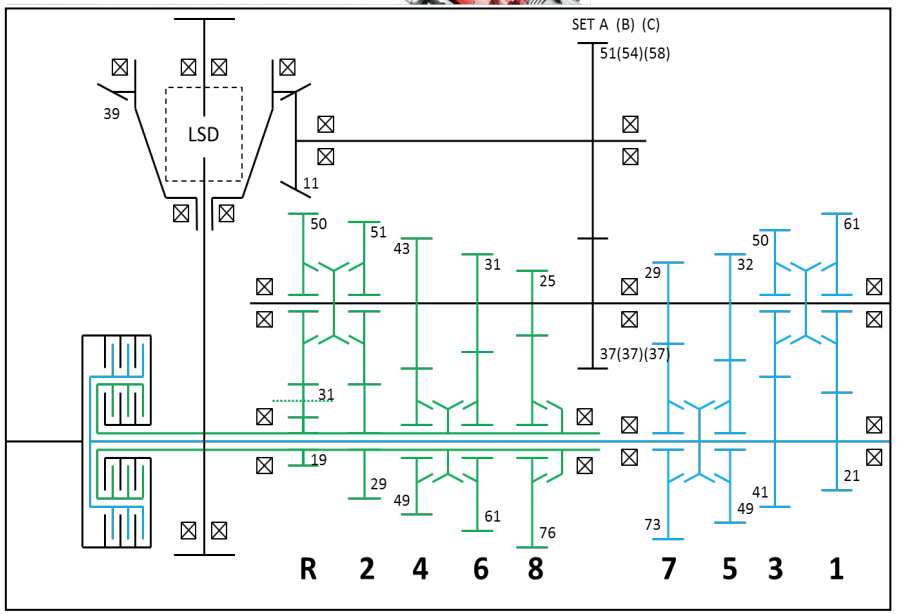
Transmissions and E-Drives have multiple rotors, gear meshes, bearings and other order sources.

To identify the source of an irregular noise, it is necessary to separate the different noise sources.









This is achieved by rotationally synchronous analysis, using the precise rotational speed information and the construction data (kinematics) of the test object.

This enables exact root cause error messages for the individual test, as well as analysis of overall production problems.

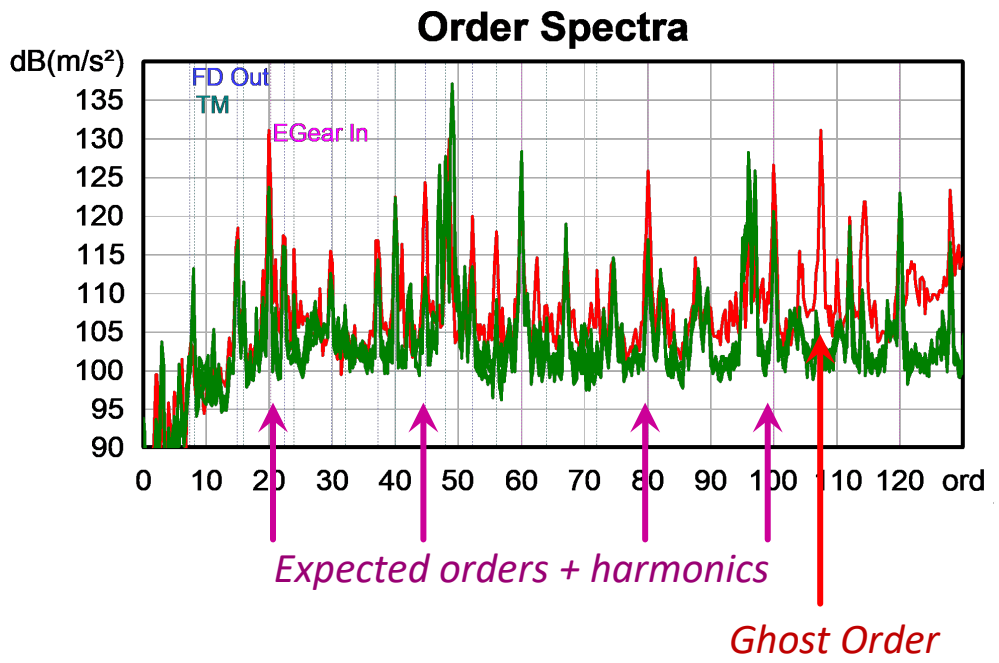
Looking at the whole picture

Gear meshes are the most prominent and important noise sources in all kinds of transmissions.

But surface patterns (waviness) on a gear can create additional order components that might be audible, and they might also indicate that the durability of the gear is reduced.

Another possible noise source are bearing defects which generate different spectral patterns which are difficult to predict.

An analysis system which only focuses on the known gear mesh orders will fail to detect ghost orders or bearing noise.

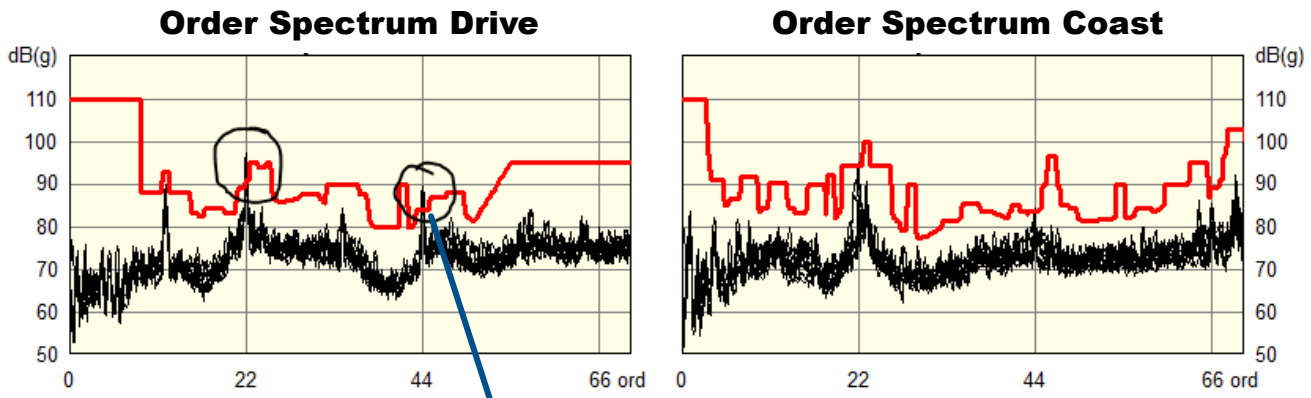


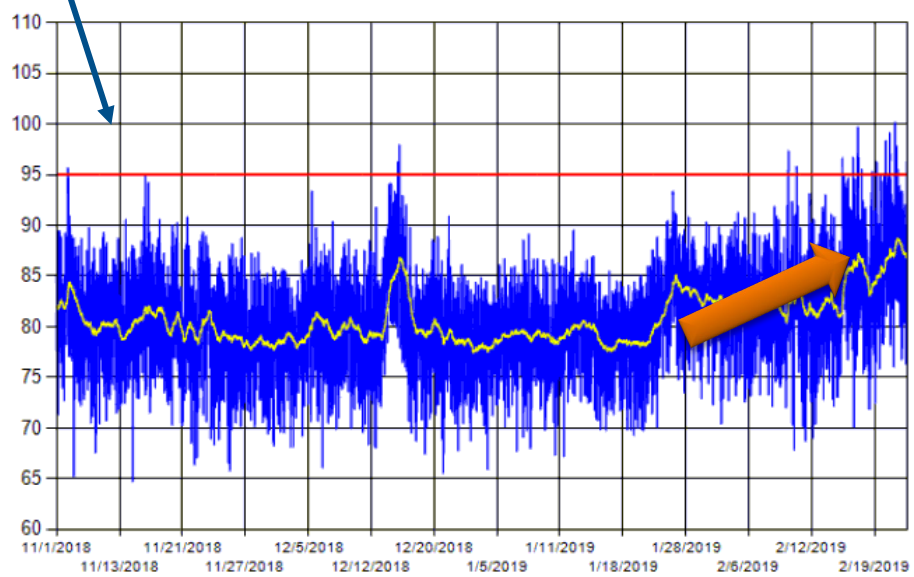
The Discom system covers both:

- Known orders are tracked over the measurement range and evaluated against limit curves or reference polygons.
- A learned spectral limit curve covers the whole spectrum and detects ghost orders without having to pre-define them.
- For known ghost orders, specific spectral value metrics can be set up, with individual limits, defect messages and value statistics.

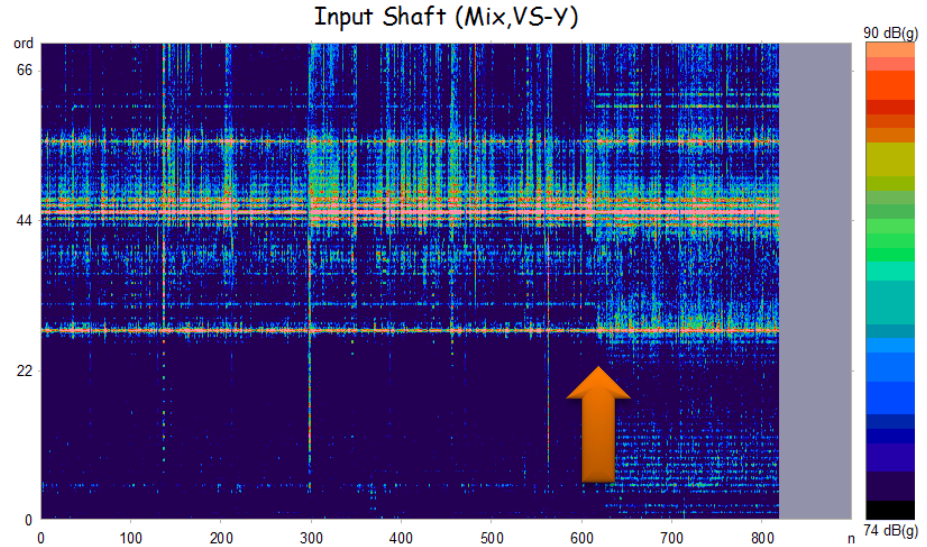
Finding Production Defects in Transmissions

Example: “Ghost Order” 22 and 44. By using Web.Pal statistical analysis, the begin of the trend could be located, and from that the problematic change in production concluded.





Web.Pal time series



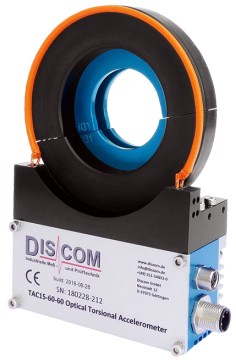
Order spectra vs. time

Gear Testing

In modern electric vehicles, controlling gear mesh noise gets even more important.

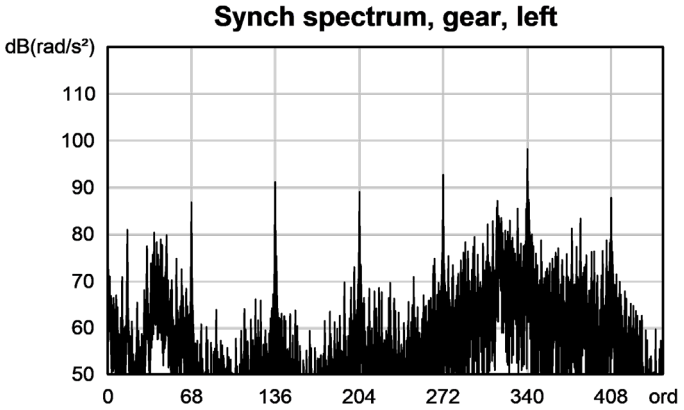
For this reason, gears are tested separately in Single Flank Gear Testers before assembly.

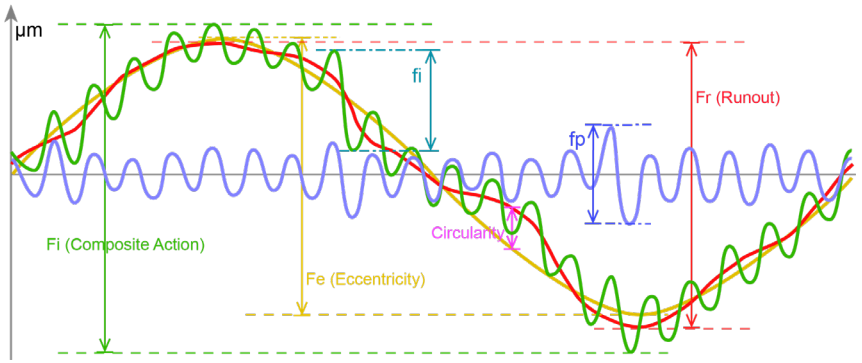
The optimum combination is using a TAC sensor for detection of surface waviness, ghost orders, contact pattern deviation and nicks, and using Transmission Error (TE) analysis for geometry evaluation, eccentricity and circularity.



TAC measurement can detect

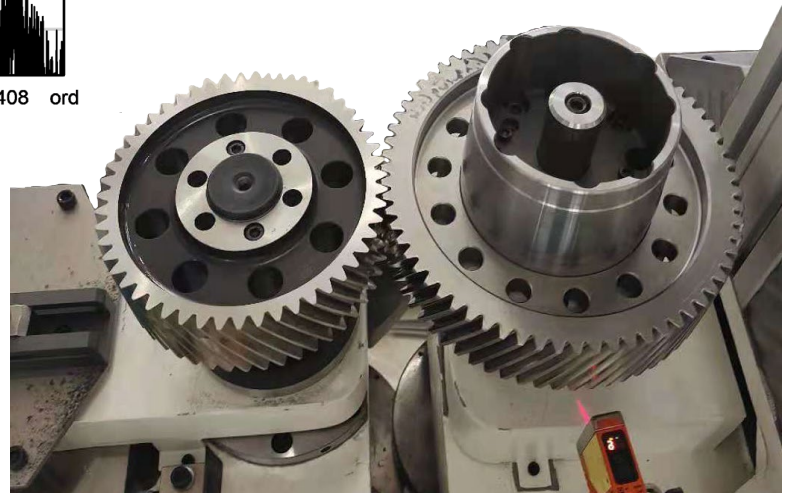
- surface waviness
- contact pattern deviations
- ghost orders
- nicks
- tooth spacing deviations





TE measurement can detect

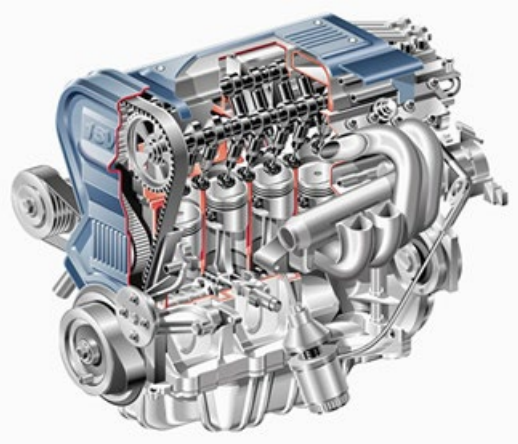
- eccentricity
- deviation from circular shape
- runout
- pitch errors

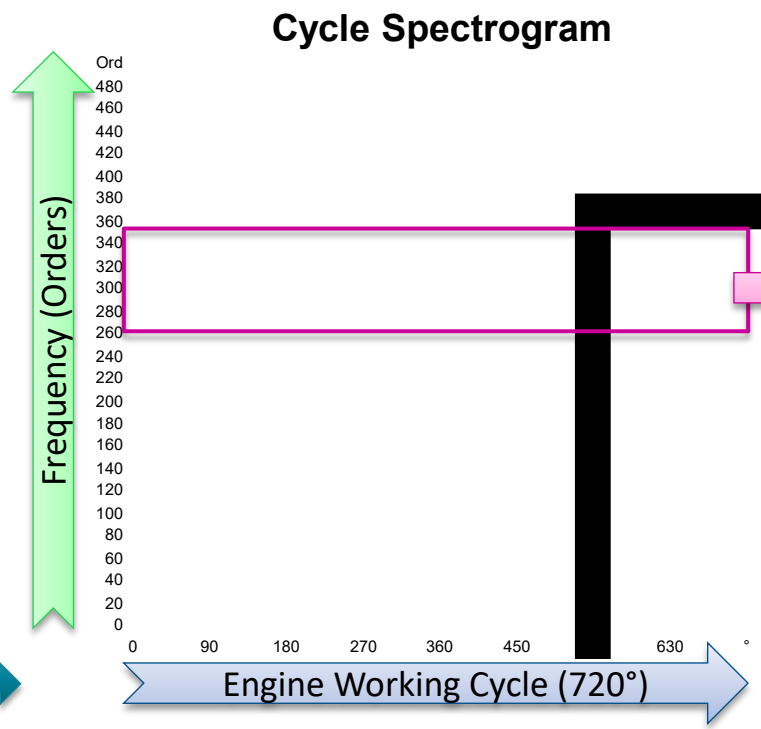


Engine Testing: Cycle Spectrogram

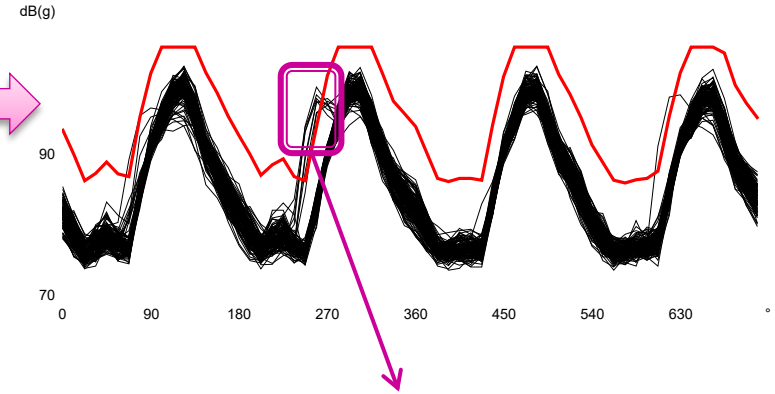
Combustion Engines produce instationary noise patterns which cannot be covered by simple spectral analysis.

A short time spectrogram calculated over the working cycle of the engine (720° crank shaft) allows the detection of pulse noises correlated to the different engine components.





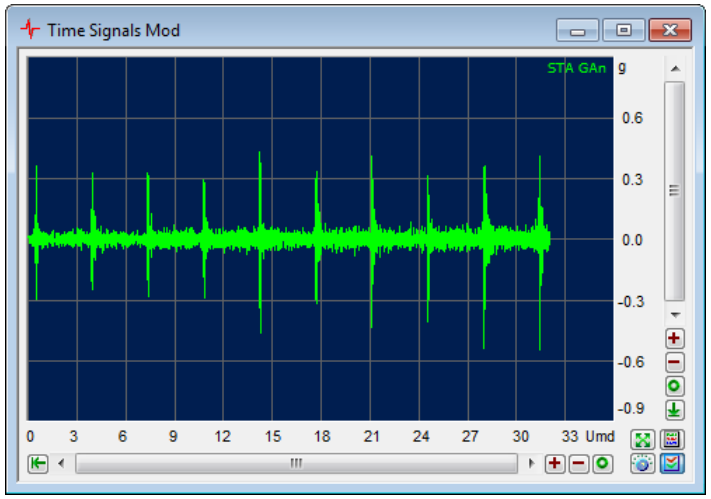
The energy in selected frequency bands is added up to create **Cycle Spectrogram Band** curves:

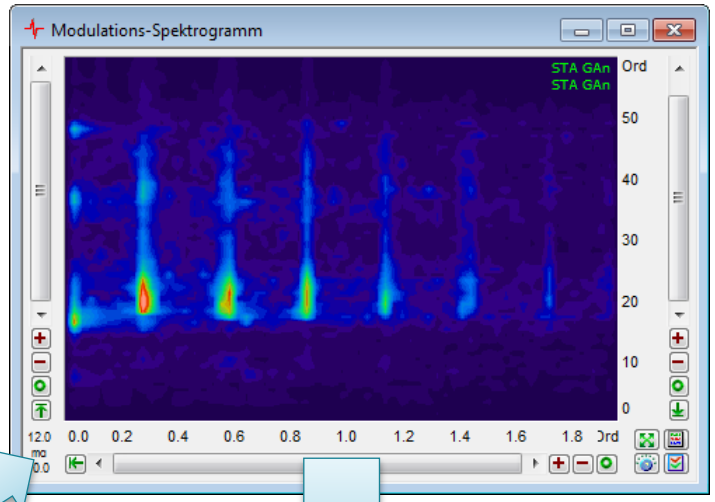


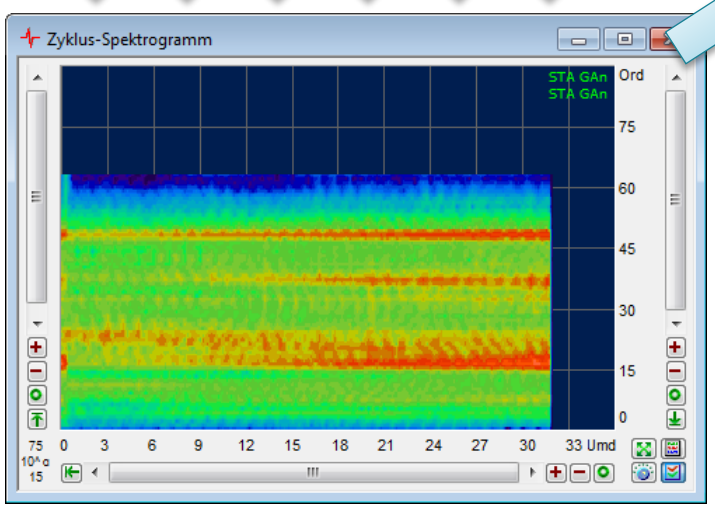
The Cycle Spectrogram Bands are evaluated against limit curves running over the angular position. This allows the detection of defects correlated to cylinders, valves etc.

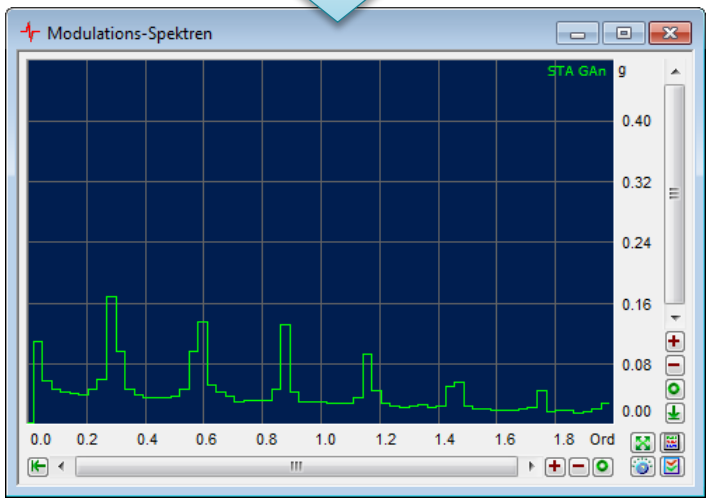
Actuator Testing with Modulation Analysis

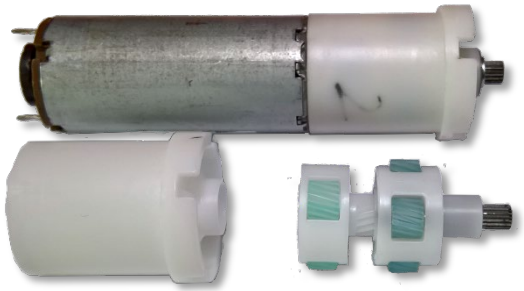
For the testing of actuators of all kinds, modulation analysis is an indispensable tool.







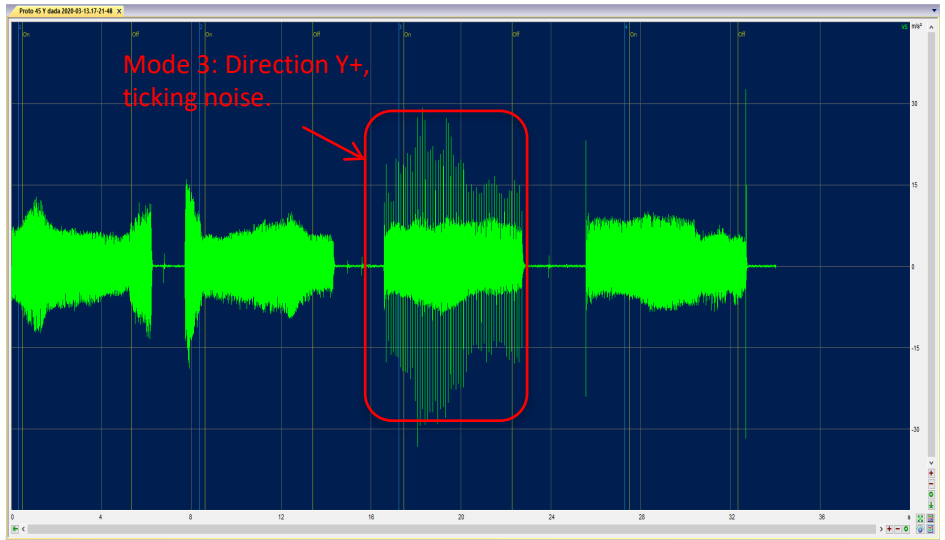


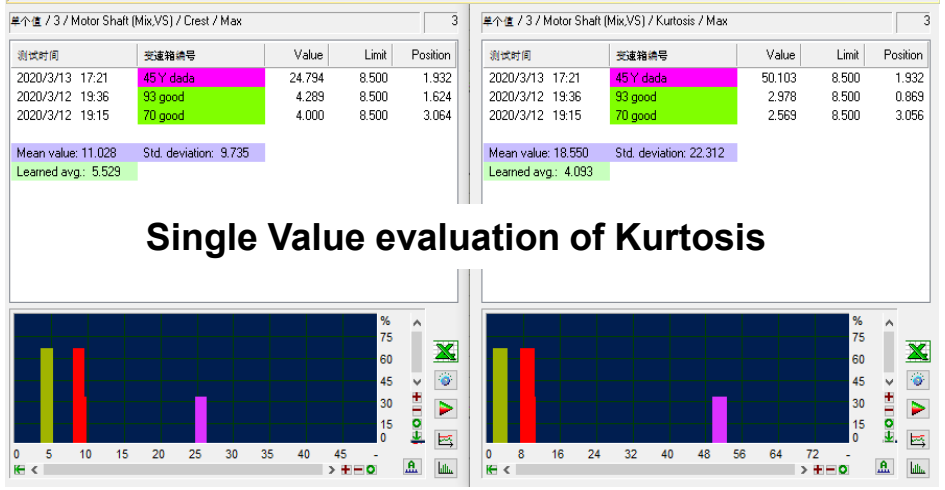


Modulation Example

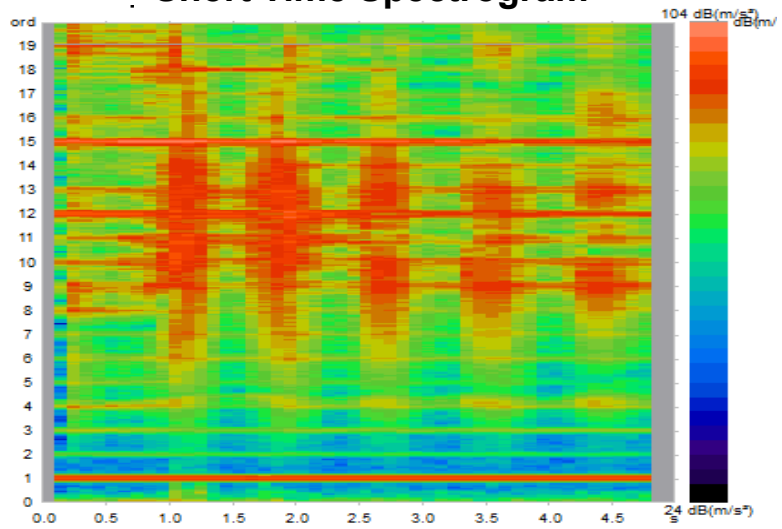
In this project, Rear Mirror electric actuators are tested using modulation analysis.

Ticking noise in the second stage leads to a modulation of the main gear mesh component.

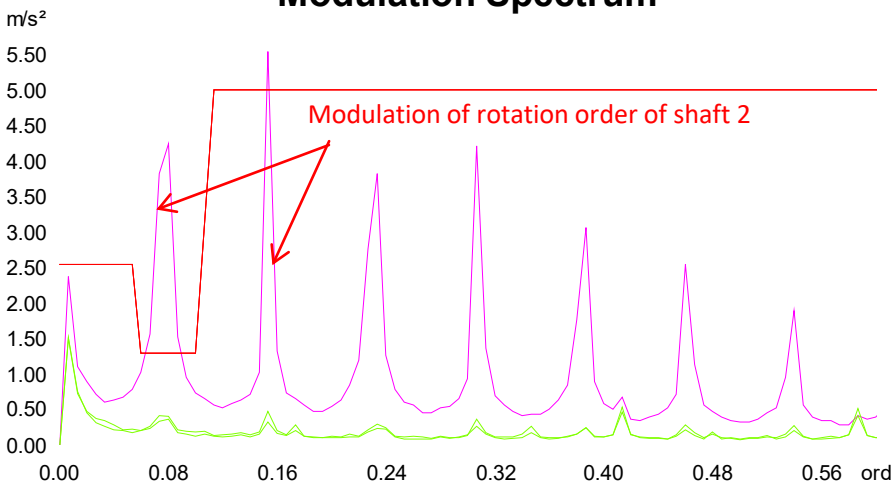




Short Time Spectrogram



Modulation Spectrum



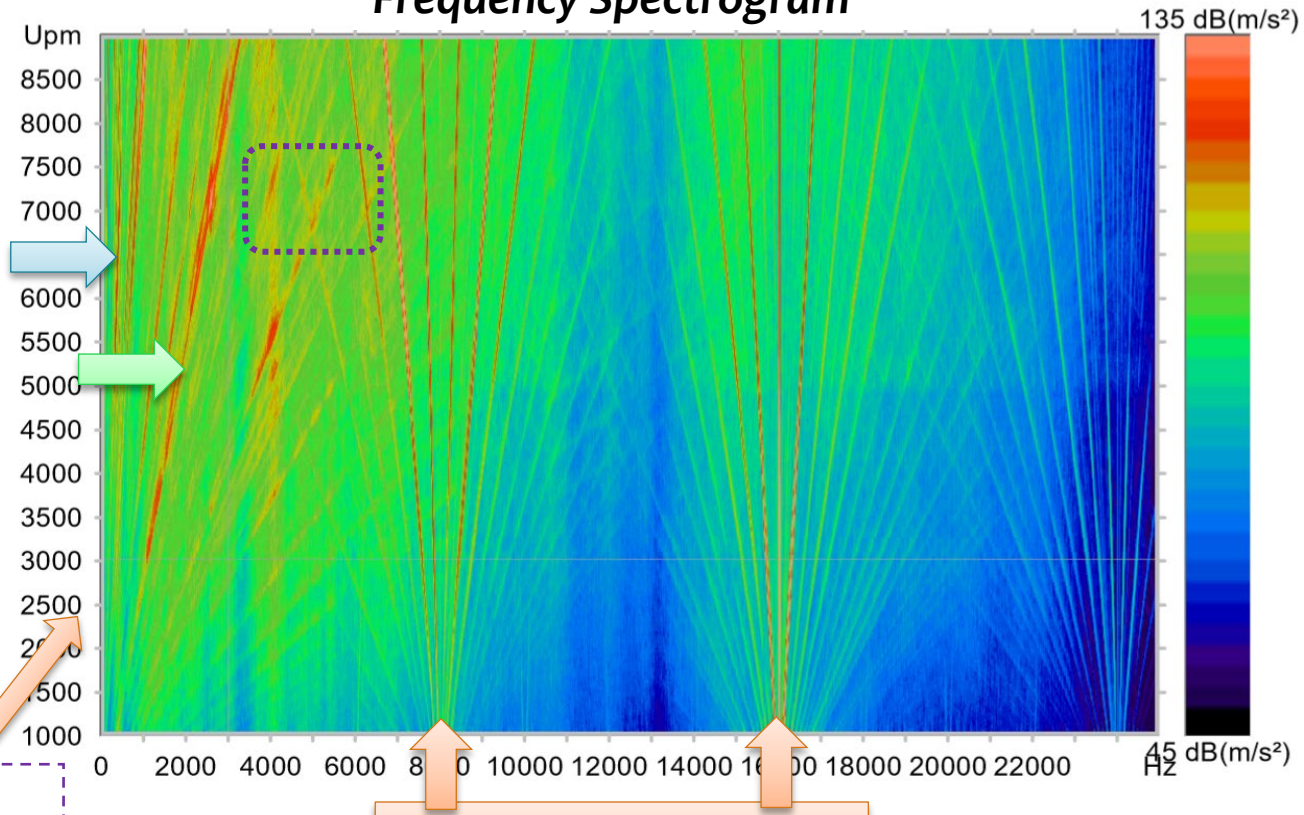
E-Drive Testing: Inverter Frequency Components

In E-Drive test, noise components from the transmission and the electric motor can be identified and separated:

Motor orders:
Slot orders
Imbalance
Bearings

Transmission orders:
Primary step
Final drive
Harmonics

Frequency Spectrogram



At certain speeds, transmission orders and inverter orders will cross and enhance each other.

Inverter frequencies:
Base frequency 8kHz
Modulation side bands
Harmonics

Tracks of motor orders, transmission orders and inverter side bands can be measured and evaluated independently.